PERFORATED NONWOVEN FABRIC AND METHOD FOR ITS MANUFACTURE

Hygiene products, such as children's diapers, incontinence products for adults or sanitary napkins, which absorb body fluids, are basically composed of an absorbent core, a sealing back made of a sheeting or a nonwoven/sheeting laminate, and facing the body, a permeable fabric made of a thin, wear-resistant, soft nonwoven or a vacuum-perforated sheeting having funnel-shaped, i.e. three-dimensional openings. The vacuum-perforated sheeting encloses the absorbent core, the largest perforation opening being directed outwardly, i.e. facing the body. The sheeting material is composed of hydrophobic thermoplastic polymer such as polyethylene, polypropylene or a copolymer made of ethylene and polymer vinyl acetate (EVA). The sheeting surface is thereby not moistened by the body fluid on the one hand, the body fluid only being conducted in the direction of the absorber core, and due to the inwardly tapering perforations, a rebound of the same is prevented, for example, in response to load, movement or pressure. As is known, in addition to predominantly cellulose, the absorber core usually also contains super absorber particles (SAP). Super absorber polymers are characterized in that they are able to absorb aqueous fluids in great quantities, and in so doing, accompanied by perceptible increase in volume, form a gel body having more or less gel firmness. The presence of SAP has the advantage that weight can be reduced and the thickness of the absorber core can thereby be diminished, and that the fluid cannot be released again in response to compressive load, and because of this, leakages can be largely prevented. However, SAP also has the disadvantage that it leads to the familiar gel blocking, and indeed, the higher its portion, the more pronounced the blocking. Understood by gel blocking is the effect that fluid can no longer be further transported, or is transported only

in a markedly retarded manner. It was also possible to solve this problem by suitable construction of the absorbent hygiene products. In this case, volume nonwoven fabrics or other very open structures which do not block upon contact with fluid are positioned between the absorber core and the covering layer. This intermediate layer absorbs fluid immediately, that is to say, removes it spontaneously from the diaper surface and distributes it uniformly. The fluid management is improved by such measures. Understood here by fluid management is the interaction of many influence variables, already partly indicated above, with the aim of producing the greatest possible comfort when wearing the hygiene article on the body.

As is known, non-perforated spunbonded materials and staple-fiber nonwovens based on polyolefins are also used as fabric for the body-side covering of the absorbent material.

Fluid management for urine in children's diapers and incontinence products for adults and for menstrual fluids in feminine hygiene is considered to be far advanced or to have reached full maturity. However, a diaper of the future should be capable of not only managing urine in an optimal manner, but also loose discharges from the intestines. Non-perforated cover nonwovens have proven to be unsuitable for this purpose. The body fluid in question is a multi-phase system having solid particles in variable form and consistency, with the tendency toward phase separation, particularly on active surfaces or surfaces with filtration and separation effect. In the following, **the** expression intestinal fluids is used for these fluids. It has turned out that non-perforated nonwoven fabrics are not suitable for completely letting through intestinal fluids and passing them on to the

absorber core. Rather, the tendency exists for solid and/or highly viscous components of the intestinal fluid to deposit on the diaper surface due to separation, and possibly to act as a barrier layer for the following body fluid having a more watery consistency. Both the separation of the coarser components as such, as well as the associated blockade for further fluid transport are serious disadvantages of conventional diapers. Therefore, numerous design approaches have been suggested for better intestinal-fluid management, all of which are based on the necessity for using perforated top sheets (covering nonwovens). In this context, the perforations should be clearly constructed. Cross bracings of individual fibers or fiber bundles, i.e. any fiber bridges have proven to be unfavorable. Over and above the perforated top sheets, the diaper construction and the formation of the open-structured nonwoven fabric situated between the covering nonwoven and the absorber core should be adapted to the particular consistency and associated properties of intestinal fluid.

Both numerous perforation methods as well as nonwoven fabrics and nonwoven composites are known. The European Patent EP-A-0 215 684 describes the production of perforations in nonwoven fabrics with the aid of the water jet method. The familiar screens are not used as the laying-up medium for the fibers and the water-jet treatment, but rather are replaced by hydroextraction cylinders in which elevations are inserted. They are responsible for a clear perforation. In the U.S. Patent 5,628,097, a different perforation method and perforation products are described, in which the nonwoven fabric is slit thermally or by ultrasound in the longitudinal direction and is stretched in the transverse direction by passages of a pair of rollers composed of two intermeshing fluted rollers. The melt-location slits are thereby separated and opened to form perforations.

Nonwoven fabrics made of staple fibers and continuous filaments, meltblown nonwovens and composite materials made of staple fibers and continuous filaments with meltblown, which, for example, are designated as SM (for spunbond/meltblown composite) or SMS (for spunbond/meltblown/~~meltblown~~ **spunbond** composite), are described.

Not only intestinal-fluid management, but also the highest possible degree of whiteness, as well as high coverage and very great softness, at least on the side facing the body, are required of a perforated nonwoven fabric in the hygiene field. It is known that both properties are dependent on the suppleness and softness of the utilized fibers themselves. They are all the higher, the lower the fiber titer is, so that the suggestion comes to use fine, finest, or even ultrafine fibers. Ultrafine fibers are also known as microfibers. They can be based on woven fabric or nonwoven fabrics. Meltblown nonwoven fabrics are also made of microfibers in the size range of approximately 1-10 microns.

A children's diaper is known from the manufacturer Unicharm which is covered with a perforated nonwoven that was produced according to the special water-jet perforation method already briefly described above, and is made from a PP/PE spunbond composite and a PP meltblown layer. It may be that this composite structure contributes to better management of the intestinal fluid, good softness on the meltblown side (= body side) and high coverage. However, this composite structure and its manufacturing method also have serious disadvantages. The meltblown layer makes no, or only a completely insignificant contribution to the total strength or overall integrity of the composite. The weights are markedly above those customary today. A reduction of

weight to below approximately 30 g/m^2 does not seem to be possible due to the high strength requirements in the machine direction for manufacturing the diaper. The high material use is cost-intensive. The meltblown layer, considered by itself alone, is not wear-resistant and, in addition to the water-jet treatment, must also be thermally anchored to the spunbond carrier nonwoven in order to prevent delamination tendencies. This in turn requires bicomponent fibers (conjugated fibers) having a centric or excentric sheathing component made of lower-melting polymer than that of the meltblown layer. Nevertheless, this perforated SM composite on the soft M side does not by far achieve the wear resistance of a PP spunbond or PP emboss-bonded staple-fiber nonwoven as are used today in diapers and sanitary napkins. For other applications, such as sealing bands on incontinence pants or operating-theater nonwovens in which wear-resistance and freedom from lint are required, only SMS can be used. With such a cover of the meltblown layer toward the body side, the advantages of the meltblown layer would no longer have an effect.

The U.S. Patent 4,840,829 describes nonwoven fabrics having a mass per unit area of 10 to 150 g/m^2, which are produced from staple fibers having a length of 20 to 100 mm and a titer of 0.555 to 16.65 dtex. These nonwoven fabrics have circular or elliptical openings which are obtained by water-jet treatment on a base provided with elevations.

Furthermore, WO98/23804 describes bonded nonwoven fabrics and methods for their manufacture, which are made of multi-component fibers and which, during their bonding to form a nonwoven fabric, are separated into their individual component fibers and intermingled.

The object of the present invention is to provide a perforated nonwoven fabric which is superior to previous nonwovens in the management of intestinal fluid, fulfills the requirements for high opaqueness and greater softness and gentleness on the body-side surface, makes a double-layer or multi-layer construction unnecessary, and makes do with a fiber-material weight which is markedly below that of perforated nonwovens used presently in diapers and sanitary napkins. It is also the object of the present invention to improve the intestinal-fluid management without impairing the urine management. It is furthermore the object of the present invention to achieve the fluid passage through the perforated nonwoven without the use of detergents, or to reduce their quantity used to a fraction of the quantities customary in non-perforated covering nonwovens.

According to the present invention, the objectives are achieved by a perforated nonwoven fabric having a mass per unit area of 7 to 25 g/m2 made of interlaced, continuous microfiber filaments, having a titer in the range from 0.05 to 0.40 dtex, which are **composed** of at least two ~~different filaments made of~~ thermoplastic polymers having different hydrophobicity and **have** a filament cross-section in ~~cake-piece~~ **pie or hollow pie form**, ~~which~~ from **which** the **split** filaments have been released ~~from fibers containing the~~, the perforations being clearly formed and being free of **split** fiber filaments.

In spite of extremely low weight, the nonwoven fabrics of the present invention exhibit very high strengths and very clear hole structures because of the low fibrous mass. In this manner, it is possible to ensure the rapid passage of body fluids, particularly intestinal fluids, without or with only small addition of surface-active

substances with low surface tension (wetting agent), and to produce a dry topsheet surface for diapers and sanitary napkins.

Each of the different filaments has a titer in the range indicated above. The perforations are preferably evenly spaced and have an individual-hole area of 0.01 to 0.60 cm^2.

The perforated nonwoven fabric of the present invention preferably has a strike-through value after one minute of less than 3 sec. The tensile strength in the longitudinal direction is preferably at least 30 N/5 cm. The rewet value is preferably less than 0.5 g.

For example, to construct the nonwoven fabric, two different filaments made of thermoplastic polymers in a weight ratio in the range from 20:80 to 80:20 can be used. In the following, the structure of the nonwoven fabric is explained on the basis of two filaments F1 and F2.

The present invention also relates to a method for producing such perforated nonwoven fabrics by laying up splittable pie or hollow pie continuous fibers, whose cross-section has at least two different thermoplastic polymers having different hydrophobicity in an alternating cake-piece arrangement, to form a nonwoven fabric, subsequent splitting and entanglement of the fibers by high-pressure water jets to form interlaced continuous filaments, followed by perforation of the nonwoven fabric formed using high-pressure water jets.

The perforation is preferably carried out on hydroextraction and hole-producing cylinders which have elevations on the surface.

In the following, first of all the polymers used for producing the nonwoven fabric of the present invention are explained, and after that the manufacturing method is further clarified.

Of the two fiber polymers F1 and F2, at least one of the two is hydrophobic and is derived preferably from the family of polyolefins such as polyethylene, polypropylene or copolymers thereof, in which one of the two is present in excess. The other can be both hydrophobic as well as hydrophilic, however is preferably not hydrophilic, but rather is less hydrophobic than polypropylene. The more strongly hydrophobic fiber polymer is designated here by F1, and the more weakly hydrophobic fiber polymer is designated by F2. F1 is preferably made of polypropylene **(PP)** or polyethylene **(PE)**, or blended from both. F2 may be a fiber from the family of polyesters, such as polyethylene terephthalate, polybutylene terephthalate, polypropylene terephthalate or a copolyester thereof and PE. Otherwise, both F1 and F2 are not subject to any restriction concerning the polymer selection, except that they have the ability to be spun to form conjugated fibers using the familiar spunbonding methods.

Of F1 and F2, both or one of the two can be made of thermoplastic elastomers. Examples for elastic polyolefins for spunbonded materials are found in EP-A-0 625 221 and for metallocene-catalyzed LLDPE in EP-A-0 713 546, in which representatives for the more weakly hydrophobic elastomers such as polyurethane, ethylene-~~poly~~-butylene copolymers, poly (ethylene-butylene ~~polys~~styrene copolymers (Kraton), poly-adipate ester and polyetherester-elastomer (Hytrel) are also described. It is known that spunbonded materials in the meltblown- or SMS combinations can be extrusion spun from these elastomers. The use of such elastomers in

F1 and/or F2 increases the softness and suppleness of the perforated microfiber nonwoven. In addition, it has turned out that only perforated nonwoven fabrics made of interlaced microfiber continuous filaments exhibit the excellent characteristics with respect to fluid management. Perforated nonwovens of microfiber staple fibers interlaced in the same way do not attain these improved characteristics. Solely because of the processing on diaper machines (high tensile force stress in the machine direction), their weight would already have to be tripled on average compared to the continuous fiber nonwoven, with perceptible losses in perforation quality, suppleness, softness, wear-resistance and fluid management.

Additions of ingredients to the polymer melt for fiber production in the form of master batches for the purposes of antistatic finishing, spin dyeing, delustring, softening, tackifying and flexibilizing the fibers, increasing and reducing the repellent properties against fluids (such as water, alcohols, hydrocarbons, oils), fats and multi-disperse systems such as intestinal fluids and other liquid excreta such as urine and menstrual fluid are also possible.

Ingredients which change the interfacial tension on the microfiber surface can also be subsequently applied after the generation, i.e. release of the microfiber filaments in the already perforated nonwoven. Such substances are, for example, wetting agents in dispersed form or dissolved in water, with which **many** diaper-cover **s**punbonded material**s** ~~is~~ **are** finished today for the purpose of better urine management.

However, the nonwoven fabrics of the present invention preferably make do without such wetting agents, or with

only a fraction of the application quantity customary till now. The development of the perforations, i.e. their hole size, their shape, the arrangement of the individual perforations relative to each other (e.g. staggered or in rows) and the open area on one hand, as well as the extremely high suppleness of the segments (area between the perforations) composed of interlaced continuous microfiber filaments and their very low weight allow this reduction in wetting agent up to the point of dispensing with it completely.

The Drawing with Figures 1 through 6 further clarifies the invention.

Figures 1 through 6 show the shape of the individual openings K and their arrangement in a fabric. In Figure 1, K is an opening, shown in idealized manner, in the form of an equal-sided hexagon, side length a being identical with b. Distance o is the shortest distance between center c of opening K and edge a. Edges a and b are in each case at a constant distance 9 with respect to each adjacent K. In each case a larger equal-sided hexagon having edges e and f and aligned parallel to a and b can be placed about individual openings K. In Figure 1, e = f. This results in a honey-comb type arrangement of openings K. Edges a and b of one opening K are in each case aligned parallel to adjacent edges a and b of adjacent openings K. Distance h = 0.59. The peaks at the contact edges a with a and a with b, respectively, are present in rounded-off form in the nonwoven. These roundings i and j of the peaks are represented in Figure 1 for the case i = j. Due to these roundings, the original distances d to e of the hexagon are shortened to q and r. In the case of Figure 1, q = r again.

In the extreme case, all roundings i and j can be so sharply expanded that a circular shape results for K, as

shown in Figure 2.

Openings K in Figure 3 differ from those in Figure 1 only in that b is markedly longer than a, and rounding i is more strongly pronounced than j.

In the extreme case, roundings i and j can be expanded to the extent that an elliptical shape results from the hexagonal K, as shown in Figure 4.

Hexagonal shapes of openings K, or such as result from the roundings, and their arrangement as shown in Figures 1 through 4 have proven to be particularly preferable for fluid management. Particularly in the case of even-sided hexagonal openings K and their rounded-off derivations, the body fluid always has the shortest path from the diaper surface into the diaper interior.

However, the invention is not restricted to such regular shapes and arrangements. Other polygons for K and their rounded-off derivatives are also conceivable, as well as irregular distributions of such or other openings. However, such openings and their arrangements which give the part of the excretory body fluid that is farthest from the opening edge an obstacle to its ability to flow off quickly through openings K are less suitable. Such arrangements are represented by way of example in Figures 5 and 6.

The distance of farthest-removed point w to the (rounded-off) corner of the square is perceptibly greater than distance h. The ratio u/h of the maximum distance to opening K, to the minimal distance should be 1/1 in the ideal case, and not over 2/1 in the worst case.

The individual hole area varies in the range from 0.01 to 0.60 cm^2, preferably between 0.04 and 0.40 cm^2. The

individual hole openings can all have the same shape and uniformly the same hole area. However, both or only one of the two can be different, although observing the aforesaid teaching of u/h less than or equal to 2/1.

The open hole area lies in the range from 8 to 40%, preferably between 12 and 35%.

Microfine, interlaced, continuous filaments S form frame L for the openings. As mentioned above, the perforated nonwoven fabric can contain surface-active agents which give it a hydrophile that is removable by washing, is removable by washing with delay, or is permanent. They are expediently applied after the water-jet perforation in the wet-into-wet process. The application quantity lies between 0 and 0.60% by weight, in relation to the weight of the nonwoven, preferably between 0 and 0.20%. The dosing goes by the area of the individual holes and the total open area. The greater both are, the more sharply the content of such surfactants can be reduced. For reasons of optimal bio-compatibility, a content of surfactants of 0% is striven for.

It has proven to be particularly advantageous not to distribute the surface-active agent (surfactant) uniformly over the entire frame, but to limit it to the immediate vicinity with respect to the hole periphery. A suction action on the fluid directed toward the perforations then compulsorily starts from this location. The multi-disperse fluid system then suffers no dewatering, i.e. phase separation. Blockage of the perforations and deposits on the frame are prevented. The fluid absorption and distribution layer, which is inserted between the absorbent core and the top sheet and is likewise adjusted to be wetting, also promotes the immediate removal of the body fluid from the diaper surface.

Producing the perforated nonwoven fabric (topsheet)

The method provides for a splittable pie or hollow pie fiber to be laid up with the aid of spunbond technology to form a nonwoven fabric of continuous filaments. The cross-sections of the unsplit fibers emerging from the die are composed of the two different polymer components F1 and F2 which string together in alternating sequence like cake pieces (normal case composed of 4 to 16 such cake pieces). As condition for a subsequent splitting, such mostly 2 polymer-chemical, sharply different components should preferably be used which exhibit only a smallest possible adhesion at their common interfaces. However, it is also possible to use chemically similar polymer components such as polyethylene terephthalate and a copolyester or polypropylene and polyethylene, provided that measures have been taken to reduce the adhesion at the interfaces of the two, for example, by the addition of an anti-tack agent in at least one fiber polymer component. If the split fiber is provided inside with a (round) cavity, one speaks of a so-called hollow pie fiber, otherwise of a pie fiber.

Before splitting, the titer of the continuous filaments in the spunbonded material as a rule is 1.0 to 4.0 dtex, preferably 1.6 to 3.3 dtex. In a first after treatment stage, the continuous filaments of the spunbonded material are subsequently interlaced using known methods of high-pressure water-jet technology (see, e.g., EP-A-0 215 684), and simultaneously split up into the cake components. Thus, when working with a pie fiber having a titer of 1.6 dtex and a total of 16 segments composed of 8 segments each of the two fiber polymers, after the splitting, microfibers are present in a titer of 0.10 dtex. Since the present invention is about a very light nonwoven fabric, it is advantageous that no screen or support with perforations be used as support upon

which the nonwoven is laid, but rather a completely unperforated support. By reflection of the water jets at this support, their rebound action can thereby be utilized, and thus energy loss can be minimized.

After the perforation, surfactant for the purpose of the superficial hydrophilizing is applied either dry or expediently beforehand in a wet-into-wet application method prior to the drying. This can be done according to the known methods of full-bath impregnation, one-sided slop-padding, spread coating or printing. In one special refinement, the surfactant (wetting agent) is imprinted in a pattern in the manner that only the fringe regions of the fiber frame with respect to the perforation are affected. This requires the creation of special printing screens which must be adapted to the perforation pattern, and special control measures for retaining the contour sharpness of the wetting-agent printing during production.

Example 1:

A spunbonded material having a mass per unit area of 13 g/m2, which is composed at 100% of a pie fiber having a fiber titer of 1.6 dtex, is laid up on a screen. The pie fiber is composed in its cross-section of 8 polypropylene segments and 8 polyethylene terephthalate segments in alternation. The size of the individual propylene segments is selected such that the parts by weight of the polypropylene makes up 30%, and that of the polyethylene terephthalate makes up 70%.

The unsplit continuous-filament nonwoven fabric is placed on a 100 mesh draining screen and bonded with a water-jet pressure of 180 mbar, and the continuous filaments are in each case split up into their 8 microfiber segments made of polypropylene and 8 microfiber segments made of

polyethylene terephthalate.

After the splitting, in each case the same number of microfiber segments of polypropylene and of polyethylene terephthalate are formed. The microfiber segments of polypropylene have an individual titer of 0.06 dtex, and the segments of polyethylene terephthalate have an individual titer of 0.14 dtex. The conversion of dtex into fiber diameter (idealized for round cross-section) yields a value of 2.36 microns for polypropylene (density of 0.91 g/cm^3) and a value of 4.42 microns for polyethylene terephthalate (density of 1.37 g/cm^3).

After the fibers have been split up by water jets, the fabric undergoes perforation, likewise with the aid of high-pressure water jets having a pressure of 70 kg/cm^2. Instead of the otherwise customary draining screen, the hydroextraction and hole-forming cylinders, having elevations on the surface of the cylinders, described in EP-A-0 215 684 are used for this purpose.

After the drying, a very soft, smooth nonwoven fabric is obtained having clearly formed perforations. The individual holes of the perforation are all (idealized) circular and of the same size. The holes are arranged in an orthogonal grating with a grating distance a, a further grating having holes being superimposed in each case in a face-centered manner.

Radius r is 1.4 mm on average, and distance a = 6.0 mm. The open area OF amounts to 34%, specific to the total area.

Concerning the perforated nonwoven fabric, the tensile strength in the longitudinal direction was measured according to EDANA 20.289, the liquid strike through time was measured according to EDANA 150.3-96, and the

coverstock wet back (also called rewet) was measured according to EDANA 151.1-96.

The strike through was repeated a total of two times after a waiting time of in each case one minute, without changing the filter-paper layers. The values indicated are in each case the average values from a total of three individual measurements.

Results:

Tensile strength in longitudinal direction: 32.3 N/5 cm

1st strike through (sec)	2nd strike through (sec)	3rd strike through (sec)
Immediately	After 1 minute	After 1 further minute
1.82	2.42	2.44

Rewet: 0.09 g

Example 2:

The perforated nonwoven fabric from Example 1 was impregnated in the foulard, using the so-called full-bath method, with an aqueous emulsion of a non-ionic wetting agent based on polysiloxane. The application quantity solid amounted to 0.042% by weight after the drying. The following test results were obtained with this sample:

Tensile strength in longitudinal direction: 30.2 N/5 cm

1st strike through (sec)	2nd strike through (sec)	3rd strike through (sec)
Immediately	After 1 minute	After 1 further minute

1.58	2.10	2.11

Rewet: 0.31 g

Comparison example 1:

A meltblown layer of 20 g/m was spun onto an emboss-bonded spunbonded material of polypropylene having continuous filaments of the titer 2.2 dtex and a mass per unit area of 10 g/m^2. The average diameter of the microfibers making up the meltblown layer was 3.82 microns. The weld area of the emboss-bonded spunbonded material was 5.2%.

This two-layer laminate was water-jet needled according to the method described in Example 1 and subsequently perforated on a conventional 20 mesh screen belt. The open area was computed at 18.4%. This two-layer nonwoven fabric was likewise very soft, but resulted in clear deficits with respect to tensile strength and strike through compared to the test values measured in Examples 1 and 2. Strike through and rewet were in each case measured on the PP meltblown side.

Tensile strength in longitudinal direction: 25.4 N/5 cm

1st strike through (sec)	2nd strike through (sec)	3rd strike through (sec)
Immediately	After 1 minute	After 1 further minute
3.81	4.92	4.96

Rewet: 0.10 g

The strike through values are clearly too high for the topsheet.

Comparison example 2:

0.40% of non-ionic wetting agent based on polysiloxane was applied on the sample from comparison example 1. As the measuring results show, it may be that the strike through can indeed be perceptibly reduced by this means, however the rewet increases disproportionately sharply. Such a high rewetting cannot be accepted in a diaper.

Results:

Tensile strength in longitudinal direction: 24.6 N/5 cm

1st strike through (sec)	2nd strike through (sec)	3rd strike through (sec)
Immediately	After 1 minute	After 1 further minute
1.23	2.35	2.40

Rewet: 2.35 g

The meltblown layer lends the topsheet a great softness. However, in the presence of wetting agent, this meltblown layer acts like a sponge. Therefore, such a construction has proven to be unsuitable for covering a suction layer.

Comparison example 3:

The two-layer construction described in comparison example 1 is subjected to a water-jet treatment according to Example 1.

The average radius r of the holes after the water-jet perforation was r = 1.28 mm. Distance a remained unchanged at a = 6.0 mm.

An open area OF = 28.6% is yielded.

Results:

Tensile strength in longitudinal direction: 24.2 N/5 cm

1st strike through (sec)	2nd strike through (sec)	3rd strike through (sec)
Immediately	After 1 minute	After 1 further minute
2.93	3.78	3.84

Rewet: 0.10 g

The strike through values are again too high.